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ABSTRACT

This program information guide describes two approaches, Cognitively Guided Instruction (CGI) and Active Mathematics Teaching (AMT), for teaching academic skills in mathematics to limited English proficient (LEP) students. CGI is based on four related teacher competencies: knowing how specific mathematical content is organized in children's minds; ability to make solving mathematical problems the content focus; ability to assess in what way students are thinking about the content in question; and ability to make instructional decisions. CGI allows students to receive basic skills instruction in a problem-solving context that is meaningful and fosters higher order thinking skills, and gives students a sense of confidence. AMT is a form of instruction developed by Good and Grouws that has proven effective in teaching large bodies of highly structured materials, such as basic mathematics skills. AMT is a structured teaching sequence typically organized into 45-minute lessons that include review (8-10 minutes), development of new content with controlled practice (20-25 minutes), and seatwork and homework (10-15 minutes). Suggestions for implementing CGI and AMT are offered, and sample activities to implement both of these approaches in the classroom are provided, including a pre-test and post-test. The activities comprise the bulk of the document. Contains 7 references. (LB)

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Innovative Strategies for Teaching Mathematics to Limited English Proficient Students

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Introduction

Limited English proficient (LEP) students are often faced with the challenge of developing both oral communication skills and academic skills in English. The development of communication skills is necessary, but it is not enough to ensure academic achievement. Learning to interpret bar graphs, for example, requires both communication skills and problem-solving skills. To succeed in the mainstream classroom, LEP students must learn both academic and communication skills. To develop academic skills, students must receive meaningful, relevant content-area instruction presented in a framework of appropriate English language development skills.

This Program Information Guide describes two approaches for teaching LEP students academic skills in mathematics, Cognitively Guided Instruction (CGI) and Active Mathematics Teaching (ATM). It also provides sample activities to implement both of these in the classroom.

Cognitively Guided Instruction

Cognitively Guided Instruction (CGI) can be an effective approach for teaching mathematics to LEP students. It can be integrated into the AMT approach or can be used as a stand-alone method. Developed by Thomas Carpenter and Elizabeth Fennema, it focuses on students' thought processes while solving mathematics problems (Carpenter, Fennema, Peterson, & Carey, 1988; Carpenter, Fennema, Peterson, Chiang, & Loef, in press). CGI is based on four related teacher competencies:

1. Teachers should know how specific mathematical content (e.g., addition and subtraction) is organized in children's minds;

2. Teachers should be able to make solving mathematical problems the content focus;

3. Teachers should be able to assess in what way their students are thinking about the content in question; and

4. Teachers should be able to make instructional decisions (e.g., sequencing of topics) based on their own knowledge of their students' thinking.

Teachers can receive training to attain these competencies through a variety of federal, state, and local programs, such as pre-service training (through teacher training programs), in-service training (through Title VII Multifunctional Resource Centers), and additional training and technical assistance from state and local sources.

Cognitively Guided Instruction can be particularly effective for teaching math to LEP students for several reasons. First, students receive basic skills instruction in a problem-solving context that is meaningful and fosters higher order thinking skills. Second, as students become proficient at problem solving, they develop confidence in their abilities

to make sense out of new problems. Third, problem solving motivates students to stay on task since it is cognitively challenging.

Suggestions for Implementing Cognitively Guided Instruction

When using Cognitively Guided Instruction, teachers and students work through the exercises in the lesson, and the teacher can ask the students how they arrived at their answers, that is, what strategies they used to answer the questions.

For example, in the graph on page 17, students can discuss how they arrived at their answers for Question 3, "What part of the world did most of the students come from?" Some students may say they looked at the chart to see which line on the graph had the least amount of students represented. Others may say they added each line and then answered the question. Others may say they were not sure how to answer the question.

With CGI, the important factor is to learn how the students ascertained their responses. Teschers should explain to them that there are several ways to solve a problem. This enables the students who answered incorrectly to learn how to arrive at the correct answer. Students can learn how to approach problems in different ways through the examples of their peers and choose the problem-solving methods with which they feel most comfortable. This increases self-confidence and the motivation to learn.

CGI can also help teachers focus on how their students solve problems. Once teachers focus on how their students solve problems, this information can be used to individualize the way the teacher approaches the content for different students. For example, the teacher may find out that some students prefer to learn mathematical rules and then apply them, while other students prefer to solve mathematical problems by trial-and-error. Implementing CGI gives the teacher additional insight into individual learning styles and allows the teacher to modify the lessons accordingly.

Active Mathematics Teaching

Active Mathematics Teaching (AMT) is a form of instruction developed by Thomas Good and Douglas Grouws (Chambers, 1987; Good & Grouws, 1977; Good, Grouws, and Ebmeier, 1983). It has proved effective in teaching large bodies of highly structured materials such as basic mathematics skills. AMT is a structured teaching sequence typically organized into a 45-minute lesson:

- Review (8-10 minutes);
- Develop New Content with Controlled Practice (20-25 minutes); and
- Seatwork and Homework (10-15 minutes).

This method of organizing instruction can also be used effectively with other content areas such as science or social studies. AMT was originally developed for whole class instruction, but it can also be used with small cooperative groups (Slavin, 1989).

Three characteristics of AMT make it especially suitable for teaching math to LEP students. First, since this method is highly organized and structured, students receive continuous reinforcement with contextual clues about both the content of the material and the structure of the lesson. Second, during the content development portion of the lesson, the teacher can modify the activities for individual students. Third, during the seatwork phase, the teacher can work individually with students who need additional instruction.

Suggestions for Implementing Active Mathematics Teaching

The following suggestions for review, content development, and seatwork can help teachers prepare their lessons using AMT.

Review

Start the lesson by telling your students very clearly what mathematics objectives they will learn that day. To reinforce your statement, write the objectives on the board before beginning the lesson. If your students are preliterate, the written objectives can be reinforced with oral repetition.

Review prior knowledge so that students can link the content of the lesson with previously acquired information. If you find that the students have forgotten that information, review it in more detail. For example, the lesson should begin with a review of yesterday's homework. To ensure that students have mastered the concepts taught in the previous lesson, review both the general concepts of the lesson and the specific math problems. During the review time, students should be given several mental computation exercises to prepare them for the activities of the lesson. State immediately whether answers are right or wrong. On Mondays, reviews should be longer (about 20 minutes) and cover the skills and concepts learned in the previous week or month.

Develop New Content with Controlled Practice

During the development phase of the AMT lesson, check prerequisite skills and concepts. Provide process explanations, illustrations, and demonstrations. For example, model how to do the problems and explain what you mean carefully and simply. Check that your students are following your explanations. Do they look puzzled? Do they provide verbal or nonverbal cues that they understand you? Try to help students understand the material by using manipulatives and concrete examples from the students' lives. For example, lessons could draw upon topics from the students' daily lives, such as favorite beverages. (See sample lessons on Page18). Also, vary the pacing of the lesson to ensure that your students understand.

As a transition to the seatwork portion of the lesson, assess your students' comprehension by having them work at some controlled practice activities that extend the concepts discussed in the lesson. To maintain on-task behavior, check students after every one or two problems. This reduces the chance of students practicing errors that will have to be corrected later. Controlled practice also provides an easy transition to individual seatwork.

Seatwork and Homework

The seatwork portion of the lesson should last about 15 minutes. It allows students to successfully practice the concepts and skills introduced in the lesson. During the controlled practice, you should have determined which students were having difficulty understanding the lesson. Now you should work with these students individually. Seatwork can be used to build success for all students, both those who can work alone and those who need extra support.

The lesson should end with a homework assignment that includes some review problems to maintain skills and some problems that extend the seatwork portion of the lesson. Homework should include more than drill and practice. It can supplement seatwork and can become the content for the next day's review.

Sample Mathematics Lessons

The sample unit in this guide on interpreting different types of graphs can be taught using the AMT concept and CGI (either separately or together) in a class for English as a second language (ESL) math students. This unit has been adapted from the Alexandria, Virginia City Public Schools ESL Math 3 Curriculum (Alexandria City Public Schools, 1988). The activities have been used with intermediate ESL students in secondary schools, but can also be used with upper elementary students, depending on their ESL levels.

Before beginning to use the graphing unit with LEP students, the teacher may want to determine the students' previous math abilities and background as well as their language proficiency and literacy levels in both their native languages and English. These factors can influence how the teacher presents the unit. For example, if the students have little or no experience with reading and interpreting graphs, are not literate in their native languages, and function at an intermediate English proficiency level, the teacher would want to spend a few days discussing graphing, demonstrating and showing examples of graphs, and having students create graphs before beginning the unit. On the other hand, if the students already know how to read and interpret graphs in their native languages and function at a high beginning level of English proficiency, the teacher would want to focus the lesson on English language structures and vocabulary rather than how to read and interpret graphs.

The sample unit can also be adapted for classes that contain students of varying levels of English and math abilities, a situation many teachers face. Instead of presenting lessons that focus on the needs of the entire class, the teacher may want to employ strategies and

techniques that emphasize the students' individual needs. For example, one technique that requires minimum preparation is to pair more advanced students with less advanced students. Another technique is to assign a more advanced student to create a series of graphs to present to the class during the lesson.

In the Alexandria City Public Schools, before beginning this unit, students take a placement exam to appropriately place them in the ESL math program. Then, the students take a pre-test. Based on their pre-test scores, the teacher determines which objectives in the unit need to be taught and which need review. Teachers also decide whether or not variables such as the number of students in the class, the presence of an instructional assistant, the length of class period, the behavior of the students and other variables permit them to individualize instruction. Therefore, the lessons in this unit are structured to accommodate either individual or whole class instruction. Whichever approach the teacher chooses, it is important to note that language development is an integral part of any content area lesson, and this is usually more efficiently achieved by whole class or small group instruction.

Organizing Lessons Using Active Mathematics Teaching

To use the unit in this Program Information Guide according to the guidelines indicated in the AMT method, the teacher might proceed as follows:

Day 1

Review (10 minutes):

Introduce unit on graphing by asking the following questions:

- What is a graph?
- Can you give me examples of graphs you have seen?
- Where have you seen these graphs?
- Why is it important to be able to read and interpret graphs?

Develop New Content with Controlled Practice (25 minutes):

Administer pre-test on graphs.

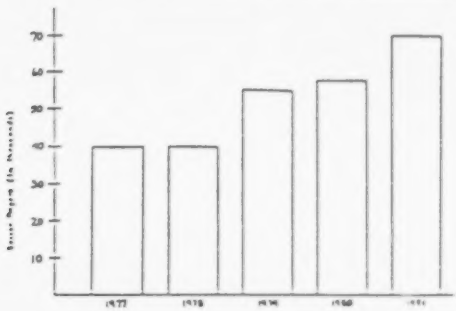
Seatwork/Homework (10 minutes):

On the board, construct a line graph of the times at which the students in the class went to bed last night.

PRE-TEST

NAME _____
DATE _____
CLASS PERIOD _____

THE GROWTH OF SOCCER IN NORTHERN VIRGINIA



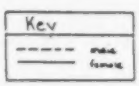
Directions: Answer the questions according to the graph.

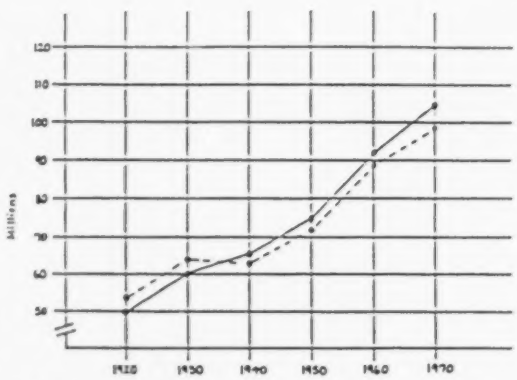
1. What type of graph is this?_____

2. In 1978, how many soccer players were there in Northern Virginia?_____

3. In which year were there more soccer players in Northern Virginia -- 1979 or 1980?
_____

POPULATION OF THE UNITED STATES





4. Does ------ represent the male or female population?_____

5. Estimate the male population in 1930._____

6. In 1950, which was greater -- the male population or the female population?_____

7. Did the female population increase or decrease from 1920 to 1960?_____

PRE-TEST
Page 2 of 2

ICE CREAM CONES EATEN IN ONE MONTH

John	8 cones
Ana	5 cones
Edgar	2½ cones
Abdul	1 cone
Vong	9½ cones

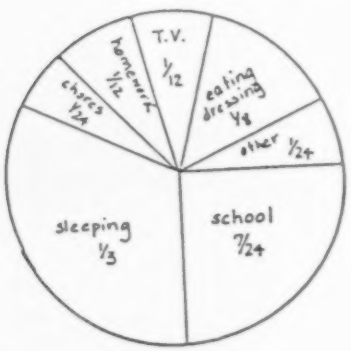
Key: = 2 ice cream cones

8a. Who ate the most ice cream cones?_____

8b. How many did he/she eat?_____

9. How many cones did Ana and Abdul eat together?_____

HOW TINA SPENDS A SCHOOL DAY



Directions: Answer the questions according to the graph.

10. What type of graph is this?_____

11. What fraction of the day does Tina spend sleeping?_____

12. What does Tina spend the most time doing?_____

Day 2

Review (8-10 minutes):

Discuss results of pre-test.

Explain what objectives will be covered in the graphing unit based on students' performance on the pre-test.

Review points made in discussion on the previous day about why graphing is important.

Write objective on board -- To Read and Interpret a Bar Graph.

Develop New Content with Controlled Practice (20-25 minutes):

Introduce bar graphs.

Work through page 9 of the unit with students.

Discuss ease of comparison with graphing.

Seatwork/Homework (10-15 minutes):

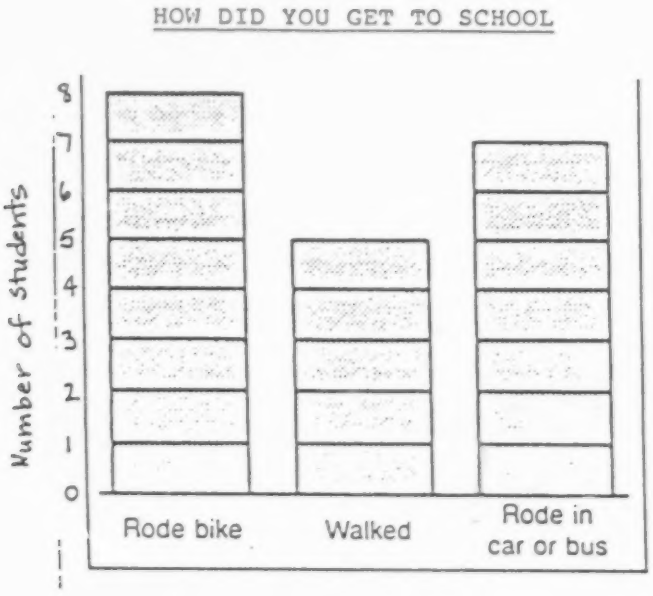
Assign page 10 as individual seatwork.

Instruct students to take page 10 home if they do not complete it in class.

Have students restate objective for the day.

OBJECTIVE: TO READ AND INTERPRET A BAR GRAPH

ESL MATH 3
Graphing Unit
Name _____

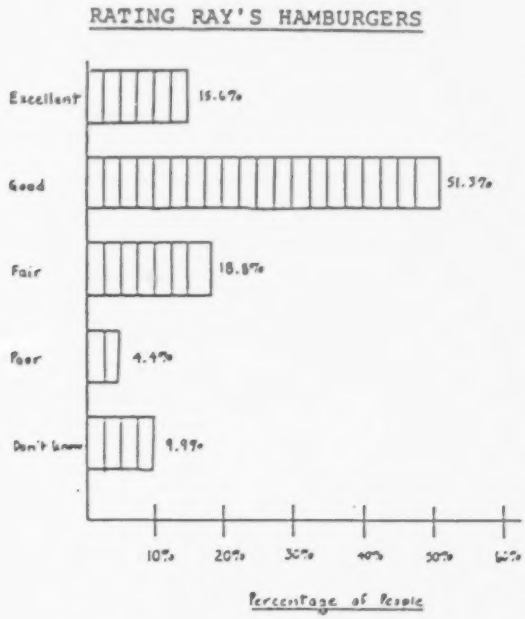


Directions: Answer the questions according to the graph.

1. How many students walked to school?_____
2. How did most students get to school?_____
3. How many more students rode in cars than walked?_____
4. How many more students rode bikes than walked?_____
5. How many students in all are shown on the graph?_____

OBJECTIVE: TO READ AND INTERPRET A BAR GRAPH

ESL MATH 3
Graphing Unit
Name _____



Directions: Answer the questions according to the graph.

1. What percentage of people think Ray's hamburgers are excellent?_____
2. What percentage of people think Ray's hamburgers are fair?_____
3. What percentage of people do not have an opinion about Ray's hamburgers?_____
4. The percentage of people who think Ray's hamburgers are _____ is 4.4%.
5. How many people out of 100 think Ray's hamburgers are good or excellent?_____
6. If 15.6% was not written next to the "excellent" bar, would you know the exact percentage of the bar or would you have to estimate the percentage?_____

Day 3

Review (8-10 minutes):

Review bar graphing.

Go over page 10 (homework from previous day).

Write objective on the board - To Read and Interpret a Line Graph.

Develop New Content with Controlled Practice (20-25 minutes):

Introduce line graphs.

Work through page 12 with students.

Discuss the use of one line, two lines, three lines, etc. on a line graph.

Seatwork/Homework (10-15 minutes):

Assign page 13 as individual seatwork.

Instruct students to take page 13 home if they do not complete it in class.

Have students restate objective for the day.

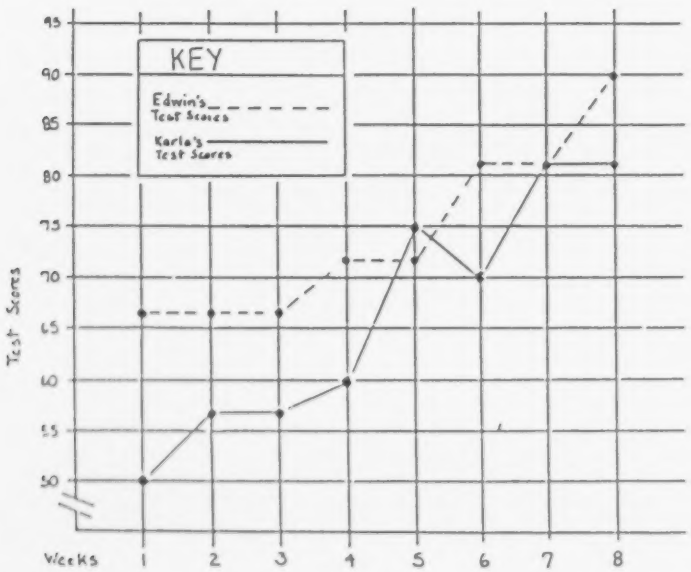
Day 4

Continue in the same manner until the end of the unit.

OBJECTIVE: TO READ AND INTERPRET A LINE GRAPH

ESL MATH 3
Graphing Unit
Name _____

MATH TEST SCORES



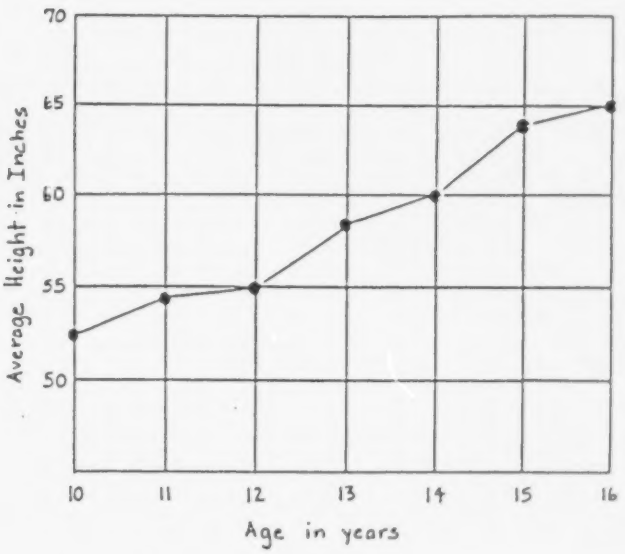
Directions: Answer the questions according to the graph.

1. Whose test scores does ——— represent?_____
2. Whose test scores does - - - - - - - represent?_____
3. What was Karla's math test score in week 6?_____
4. What was Edwin's math test score in week 7?_____
5. Whose score was higher in week 2?_____
6. What week did Karla and Edwin have the same score?_____
7. Between week 1 and week 2, who improved his/her math score the most?_____
8. What week were Karla's math scores better than Edwin's math scores?_____

OBJECTIVE: TO READ AND INTERPRET A LINE GRAPH

ESL MATH 3
Graphing Unit
Name _____

AVERAGE HEIGHT OF BOYS AT VARIOUS AGES



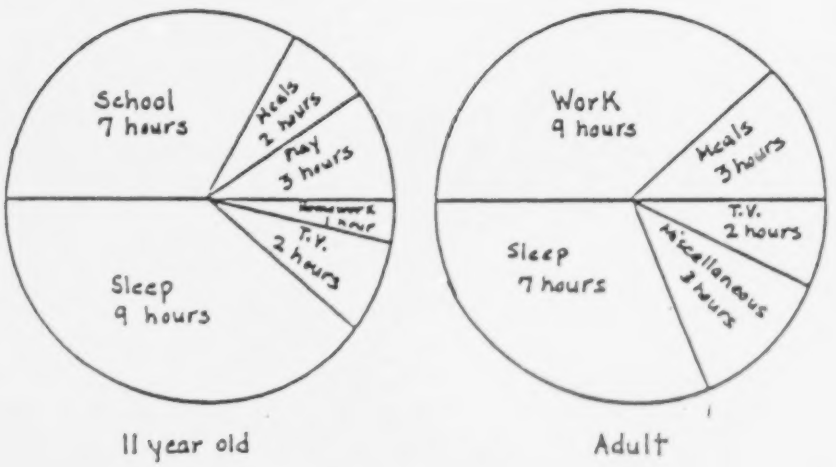
Directions: Answer the questions according to the graph.

1. What ages are represented on this graph?_____
2. What is the average height of a 14 year old boy?_____
3. What is the average height of a 13 year old boy?_____
4. A boy who is 65 inches tall is _____ years old.
5. As a boy gets older does his average height increase or decrease?_____
6. From this graph, what do you think the average height of a 9 year old boy would be?
   _____

OBJECTIVE: TO READ AND INTERPRET A CIRCLE GRAPH

ESL MATH 3
Graphing Unit
Name _____

HOW THE DAY IS SPENT



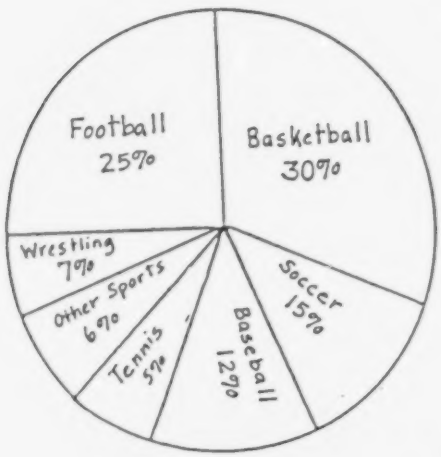
Directions: Answer the questions according to the graph.

1. How many hours per day does the 11 year old spend eating?_____
2. How many hours per day does the adult work?_____
3. How many more hours per day does the 11 year old sleep than the adult?_____
4. How many hours per day does the 11 year old spend in school and doing homework?_____
5. What activity does the adult spend the most time doing per day?_____
6. What fractional part of the day does the 11 year old spend playing? (Reminder: there are 24 hours in a day.)_____
7. What fractional part of the day does the adult spend watching t.v.?_____

OBJECTIVE: TO READ AND INTERPRET A CIRCLE GRAPH

ESL MATH 3
Graphing Unit
Name _____

FAVORITE SPORTS OF MAINE HIGH SCHOOL STUDENTS



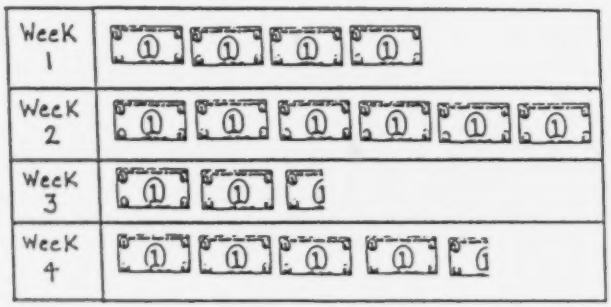
Directions: Answer the questions according to the graph.

1. What is the favorite sport of Maine High School students?_____
2. What is the least favorite sport of Maine High School students?_____
3. What percentage of students prefer soccer as their favorite sport?_____
4. What percentage of students prefer wrestling as their favorite sport?_____
5. How many students out of 100 prefer football?_____
6. How many students out of 100 prefer football or baseball?_____
7. Which sport is more popular at Maine High School -- baseball or soccer?_____

OBJECTIVE: TO READ AND INTERPRET A PICTOGRAPH

ESL MATH 3
Graphing Unit
Name _____

MONEY MARIA EARNED BABYSITTING



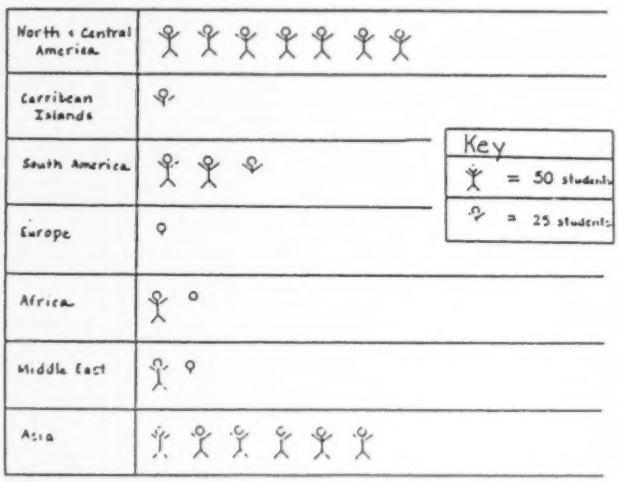
Directions: Answer the questions according to the graph.

1. How much money does represent?_____
2. How much money does represent?_____
3. How much did Maria earn in week 1?_____
4. How much did Maria earn in week 2?_____
5. How much did Maria earn in week 3?_____
6. How much did Maria earn in week 4?_____
7. Which week did Maria earn the most money?_____
8. Which week did Maria earn the least money?_____
9. How much money did Maria earn in 4 weeks?_____

OBJECTIVE: TO READ AND INTERPRET A PICTOGRAPH

ESL MATH 3
Graphing Unit
Name _____

PLACES ALEXANDRIA ESL STUDENTS CAME FROM



Source: Alex. City Public School

Directions: Answer the questions according to the graph.

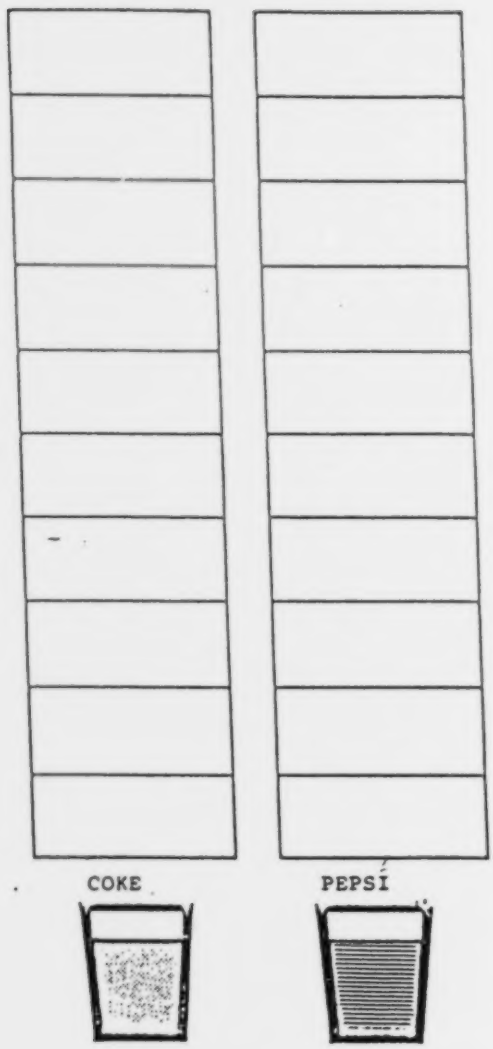
1. How many people does represent?_____
2. How many people does represent?_____
3. What part of the world did most of the students come from?_____
4. What part of the world did the fewest students come from?_____
5. Approximately how many people came from South America?_____
6. Approximately how many people came from the Middle East and Asia?_____
7. Approximately how many people came from Africa?_____
8. Show how you would represent 100 people with the figure. _____

OBJECTIVE: TO CONSTRUCT A GRAPH WITH GIVEN INFORMATION

ESL MATH 3
Graphing Unit
Name _____

TAKE A POLL

Ask ten classmates which kind of soda they like best. Start at the bottom of the chart and write each student's name in the box above the soda they like best.



When you are finished, answer the questions:

1. How many people like Coke best?_____
2. How many people like Pepsi best?_____
3. Which soda do more people like the best?_____
4. How many more people like that soda the best?
   _____

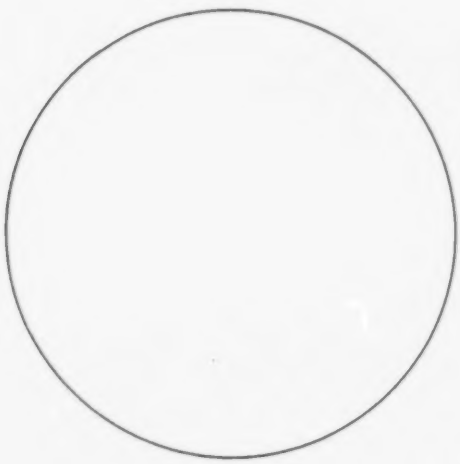
OBJECTIVE: TO CONSTRUCT A GRAPH WITH GIVEN INFORMATION

ESL MATH 3
Graphing Unit
Name _____

HOW DO YOU SPEND YOUR TIME?

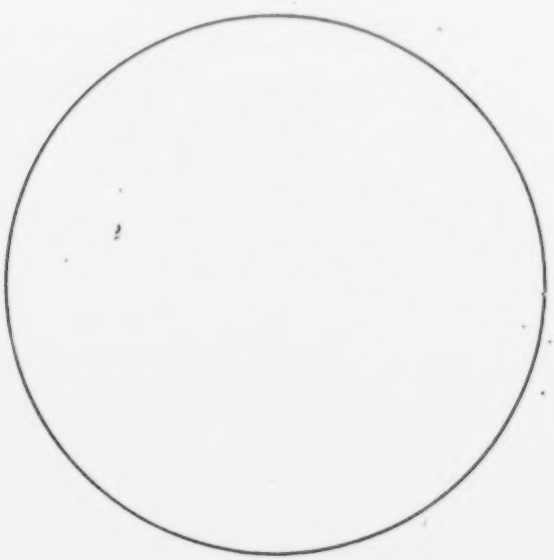
1. Make a graph in the circle below to show how you spend your time during the day.

My Time



2. Make a graph in the circle below to show how one of your friends spends his/her time during the day.

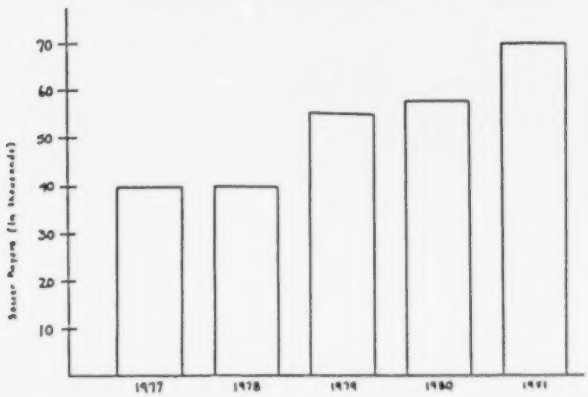
My Friend's Time



POST-TEST 15

ESL MATH 3
Graphing Unit
Name _____
Date _____
Class Period _____

THE GROWTH OF SOCCER IN NORTHERN VIRGINIA



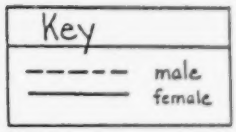
Directions: Answer the questions according to the graph.

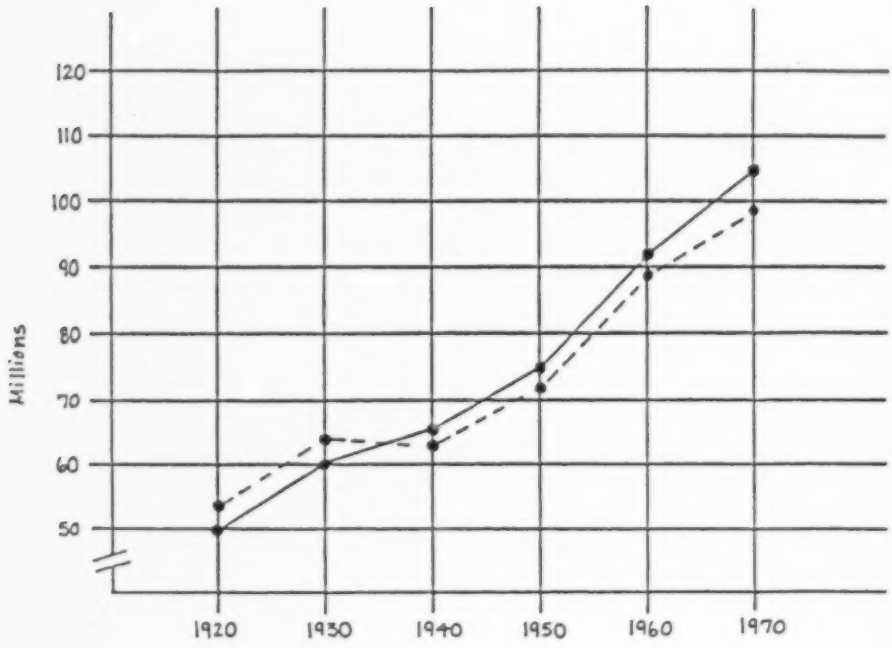
1. What type of graph is this?_____
2. What years are shown on the graph?_____
3. In 1979, how many soccer players were there in Northern Virginia?_____
4. In 1981, were there more or fewer soccer players in Northern Virginia than in 1980? _____
5. In which year were there more soccer players in Northern Virginia -- 1979 or 1981? _____
6. In which two years were there exactly the same number of soccer players in Northern Virginia?_____
7. From this graph, can you tell how many soccer players there were in Northern Virginia in 1975?_____ Why or why not?_____

_____

POPULATION OF THE UNITED STATES

ESL Math 3
Graphing Unit Test
Page 2 of 4





Directions: Answer the questions according to the graph.

8. Does - - - - - - represent the male or female population?_____

9. Estimate the male population in 1920._____

10. Estimate the female population in 1970._____

11. Estimate the total population in 1930._____

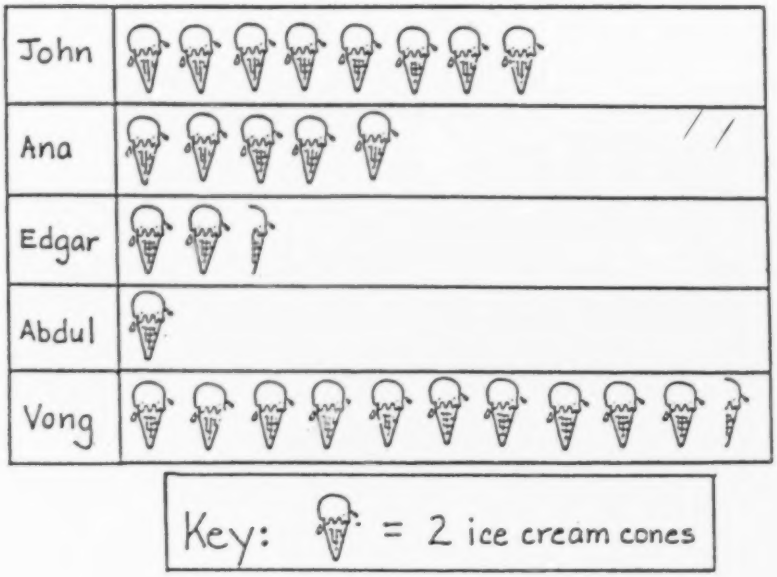
12. In 1940, which was greater -- the male population or the female population?_____

13. Did the female population increase or decrease from 1920 to 1970?_____

14. For which years was the male population greater than the female population?_____

15. Which do you think was greater in 1910 -- the male population or the female population?_____

ICE CREAM CONES EATEN IN ONE MONTH



Directions: Answer the questions according to the graph.

16. What type of graph is this?_____
17. How many ice cream cones does represent?_____
18. How many ice cream cones does represent?_____
19. How many ice cream cones did John eat?_____
20. How many ice cream cones did Abdul eat?_____
21. Who ate the most ice cream cones?_____
22. How many did he/she eat?_____
23. How many cones did Ana and Edgar eat together?_____
24. How many more ice cream cones did Vong eat than Abdul?_____
25. Show how you would represent 13 ice cream cones._____

26. Use the information listed below to construct a circle graph about President Bush.

President Bush spends

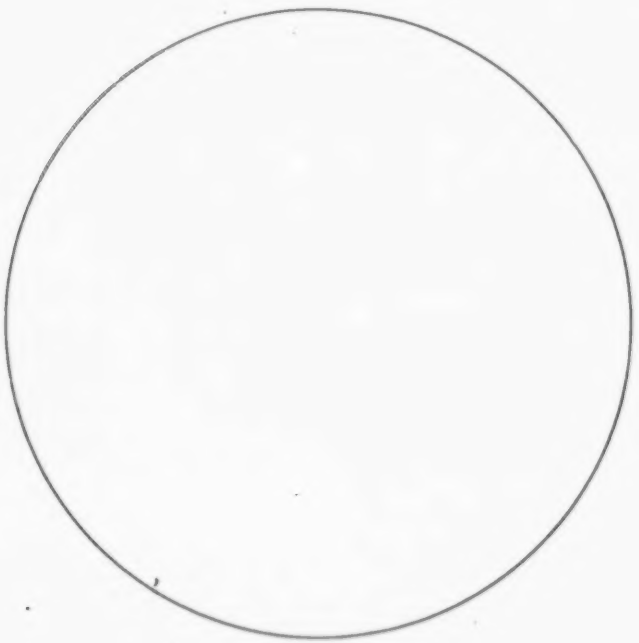
3/8 of his day in his office

1/8 of his day at receptions

1/8 of his day with his family

1/8 of his day exercising

2/8 of his day sleeping



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